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F2P

## (54) Sewer relining

(57) A run of an existing sewer (10) having at least one lateral sewer line (12,13) connected thereto is relined by applying an identifiable marking (14) to the wall of the existing sewer (10) or lateral (12,13), the marking being applied at a predetermined position relative to the mouth (15) by which the lateral is connected to the sewer, the marking being formed from a composition which includes magnetically detectable material. A liner (11) of plastics material is introduced into the run of the existing sewer, which liner overlies the mouth (15) of the lateral. The predetermined position of the marking (14) is magnetically detected with a detector 21, a cutter (22) is applied to the wall of the liner (11), following detection of the position of the marking (14), at a position which is in registry with the mouth (15) of the lateral, and the wall of the liner is then cut-through to communicate with the mouth of the lateral.

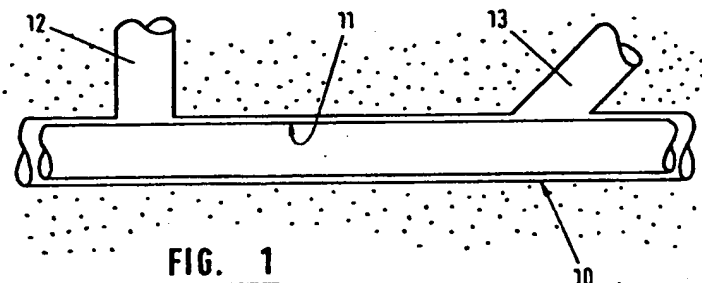


FIG. 1

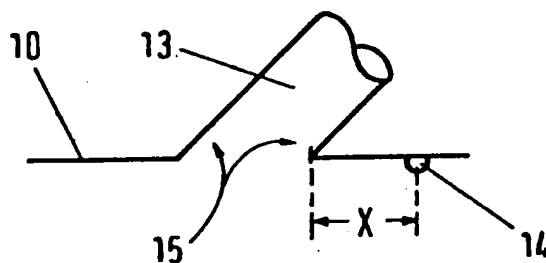


FIG. 2

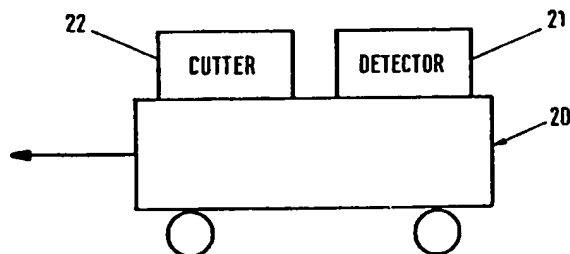
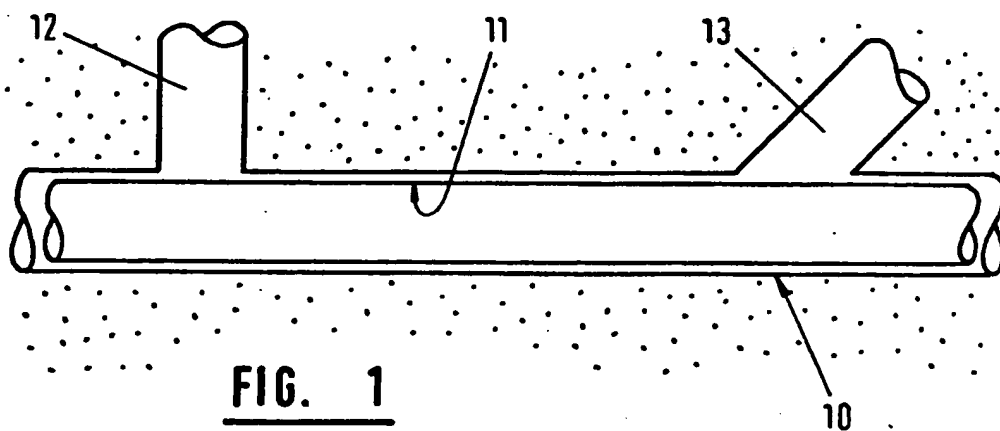


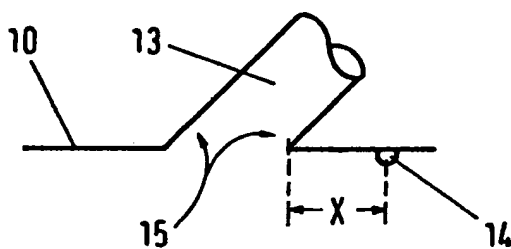
FIG. 4

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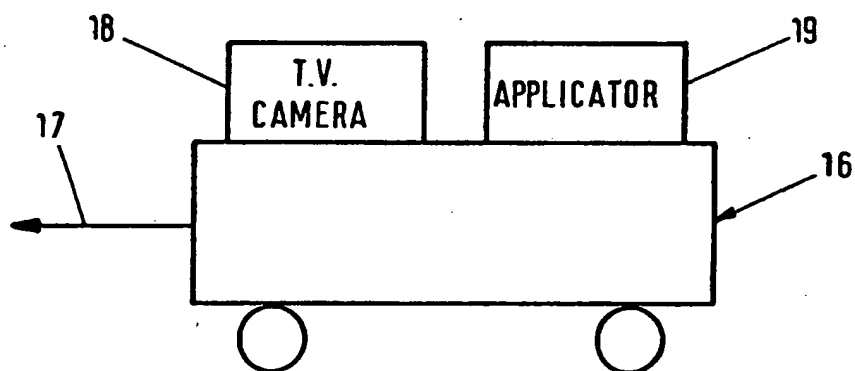
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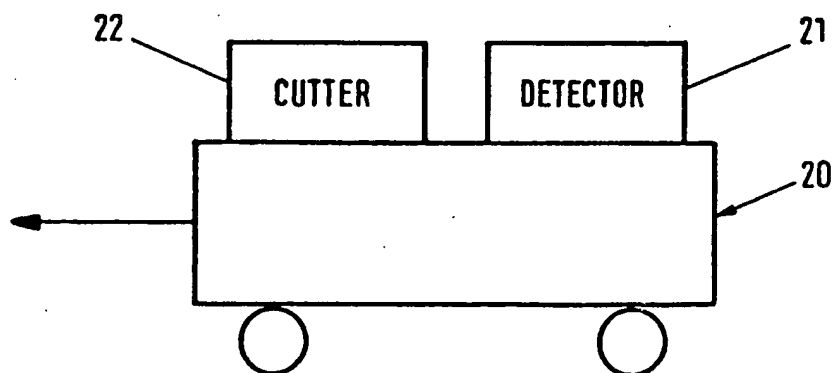
**FIG. 1**



**FIG. 2**



**FIG. 3**



**FIG. 4**

## SPECIFICATION

### Sewer re-lining

- 5 This invention relates to the re-lining of existing sewers.

It is known to renovate or re-line an existing sewer using a liner of plastics material which is introduced into the sewer and which lies with its outer surface adjacent to and/or in contact with the inner surface of the existing sewer. When a plastics material liner is used, the liner can be pre-formed and then drawn or pushed into the required position along the sewer. Alternatively, there are known techniques whereby a liner is simultaneously formed and positioned within the sewer. A type of extrusion technique may be employed for the simultaneous forming and positioning of a liner.

However, bearing in mind that sewers are pierced laterally at frequent intervals along their lengths to allow connecting sewer lines, so called "laterals", to be connected therewith, there is a major problem in locating the position of these laterals after the re-lining has taken place. This problem exists for both of the above described means of introducing a new liner into an existing sewer.

It will be appreciated that the spacing-apart of laterals in an existing sewer will be dictated by the geography of the area through which the sewer is taken, and there will be no standard spacing between successive laterals. Therefore, it is not readily possible to pre-mould, or pre-form liners with apertures which can be accurately brought into register with the laterals of any particular run of sewer which is to be renovated.

Accordingly, various techniques have been developed in order to enable the mouths to laterals to be located after a new liner has been placed in position. One technique employs solid magnets which are introduced into the mouth of the lateral, prior to positioning of the new liner, and which are held in position by spring-clip arrangements, each of which carries a respective magnet and is retained in a desired position by spring clamping engagement with the walls of the lateral adjacent to its mouth. After introduction of the new liner into a given sewer run, all of the mouths of the laterals in that run are covered by the new liner. The position of the mouths is then detected using sensing devices, such as magnetic compasses or Hall effect switches, and a cutter is used to pierce the wall of the new liner in registry with the now-detected position of the mouths of each of the laterals. The spring-clip magnetic arrangement in each mouth must then be removed for future use, since otherwise it could be the cause of future obstruction.

The typical diameter of a sewer is in the range 4 inches to 24 inches so that it is

therefore necessary to use robots which are remotely operated e.g. by an operator at ground level or at one end of a sewer run, in order to carry out the sequence of operations referred to above. Usually, the robot carries a television camera (CCTV camera) to enable the operations to be remotely monitored and controlled, and the robot is usually drawn by a cable along a sewer run, though it can also be self-propelled.

By positioning the solid magnets in the mouth of each lateral, the magnetic sensing device which is used subsequently to locate the magnet will obviously have to be positioned in registry with the mouth, and will therefore be in the way of the cutter which is used to pierce the wall of the new liner. Therefore, after locating the magnet, the sensing device then has to be moved out of the way of the cutter, and the cutter has to be brought into the required cutting position. Evidently, with remote observation and control, this can give rise to inaccuracies in the location of the pierced hole in the wall of the liner.

Therefore, the existing technique suffers from the disadvantages that it is necessary (a) to preposition a recoverable magnet in the mouth of each lateral, (b) to remove the magnetic sensing device from the path of the cutter after each detection operation, and (c) finally to recover each magnet and spring clip retainer arrangement. This sequence of operations (which is not always sufficiently accurate in registering the pierced hole in the wall of the liner with the mouth of each lateral) has to be carried out at each lateral, and is therefore time-consuming.

Accordingly, there has developed a need to provide a sewer renovation or re-lining technique which is simpler to operate, more reliably accurate in operation, and which can be carried out on a semi-continuous basis from one lateral to another.

According to a first aspect of the invention there is provided a method of re-lining a run of an existing sewer having at least one lateral sewer line connected thereto, the method comprising:

115 applying an identifiable marking to the wall of the existing sewer or lateral, the marking being applied at a predetermined position relative to the mouth by which the lateral is connected to the sewer, and the marking being formed from a composition which includes magnetically detectable material;

120 introducing a liner of plastics material into the run of the existing sewer, which liner overlies the mouth of the lateral;

125 magnetically detecting the predetermined position of the marking;

130 applying a cutter to the wall of the liner, following detection of the position of the marking, at a position which is in registry with the mouth of the lateral;

and cutting-through the wall of the liner to communicate with the mouth of the lateral.

By applying the marking at a predetermined position in relation to the mouth of the lateral e.g. spaced a predetermined distance therefrom on the wall of the existing sewer run, the cutter can be spaced by the same distance from a magnetic detecting device, and will therefore be brought automatically into the required position for cutting-through the wall of the liner in registry with the mouth of the lateral when the detecting device is positioned over the marking. There is therefore no need to move the detecting device out of the way, following detection of the marking, prior to positioning and then operation of the cutter, as in the existing technique.

Furthermore, by applying a marking which contains magnetically detectable material e.g. in the manner of a spot or blob of paint or paste, and which can be supplied relatively inexpensively as compared with the existing spring-clamping magnet arrangement, there is no need to recover the marking material which can remain on the wall of the sewer and covered by the new liner. Also, the marking material will not form a subsequent obstacle in service of the re-lined sewer installation.

Following each step of lateral locationing and subsequent liner wall piercing, the cutter and detecting device can be readily moved along the liner to carry out detection and hole-forming at the next lateral location covered by the liner, or by another liner. This therefore enables the method to be carried out on a semicontinuous basis, which is a distinct improvement over the existing technique, which involves the carrying out of a greater number of separate operational steps at each lateral.

It is preferred that a sensitive magnetic detecting device be used, which can respond accurately to the presence of small magnetic fields, and one particularly suitable device is a magnetometer, and especially a flux gate magnetometer.

The marking composition may be liquid or semiliquid based, so as to be applied like paint or paste. The magnetically detectable component of the marking may take any suitable form, such as fine magnetic particles which are held in a suitable carrier medium.

While it is preferred that the marking should be applied on the wall of the sewer at a position near to the mouth of the lateral, this is not essential to the invention, and the predetermined position of the marking may indeed be on the wall of the lateral sewer connection.

The application of the marking may be carried out using a remotely operated robot which carries a television camera to enable visual inspection of the lateral during an initial survey or inspection of the sewer run. The robot also carries an applicator which can be remotely operated in order to apply the mark-

ing material at the required position following observation of the mouth of the lateral by the camera.

The magnetic detecting device and the cutter may be provided on a separately operated robot which is drawn, pushed, or self-propelled along the interior of the new liner in order to locate each lateral and then form a hole in the wall of the liner in registry with the mouth of the lateral. Alternatively, the magnetic detecting device and the cutter may be mounted on the same robot which carries the T.V. camera and the marking applicator.

The manner by which the new liner is introduced into the existing sewer run is not critical, and may take any of conventionally employed techniques. For example, the liner may be pre-formed by extrusion, and then mechanically fed into, or drawn along the sewer run. Alternatively, the liner may be formed simultaneously with its being positioned adjacent to the inner wall of the sewer.

According to a further aspect, the invention provides apparatus for carrying out the first aspect of the invention.

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawing in which:

Figure 1 is a schematic illustration of an existing sewer run which is being re-lined using method and apparatus according to the invention;

Figure 2 is a detailed view of a part of the existing sewer run, in the region of a lateral sewer connection, and prior to introduction of a new liner;

Figure 3 is a schematic illustration of a remotely operated robot for use in carrying out relining or renovation of the sewer run shown in Figures 1 and 2; and

Figure 4 is a schematic illustration of a further robot for use in the renovation or relining of the sewer.

Referring now to Figures 1 and 2 of the drawings, there is shown schematically an existing sewer run 10 which is in need of renovation or re-lining. Typically, the sewer 10 will have a diameter in the range 4 inches to 24 inches. The sewer 10 will be formed from any of the materials currently in use in sewage installations in this country, including brickwork, clayware pipe and concrete pipe.

The sewer 10 has connecting sewer lines 12 and 13, so called "laterals" which are connected thereto, and the spacing-apart of the laterals 12 and 13 will be dependent upon the geography of the area through which the sewer 10 is taken. By way of example only, the lateral 12 is a T connection, whereas lateral 13 is an oblique connection.

In Figure 1, a new liner 11 is illustrated, which has been introduced into the existing sewer 10 by any suitable technique, including conventionally used techniques. Thus, the

liner 11, which is preferably of plastics material, may be pre-formed by extrusion, and then fed, or drawn along the sewer. Alternatively, the liner 11 may be formed and positioned simultaneously, using extrusion apparatus within, or at one end of the sewer 10.

Referring to Figure 2, there is shown a detail of the sewer 10 adjacent to the lateral connection 13, and prior to introduction of the liner 11. Evidently, having regard to Figure 1, following introduction of the liner 11, it will be necessary to pierce the wall of the liner 11 at locations which are in registry with the mouths of the lateral connections 12 and 13 to the sewer run 10. To enable the position of the mouths of the laterals to be located, following introduction of the liner 11, an identifiable marking 14 is applied to the wall of the existing sewer 10, as shown in Figure 2, and this marking 14 is applied at a predetermined position relative to the mouth 15 by which the lateral 13 is connected to the sewer 10. However, though not shown, it should be understood that the predetermined position of the marking 14, relative to the mouth 15, may also be achieved by application of the marking on the wall of the lateral connection 13 adjacent to the mouth 15.

The marking 14 is applied as a blob, spot or small coating in the manner of paint or paste, by an applicator which is described in more detail below. The marking 14 is formed from a composition which includes magnetically detectable material, such as fine magnetic particles held in a suitable carrier medium.

During the initial surveying and inspection of the sewer 10, markings 14 will be applied at predetermined positions in relation to the mouth of each lateral e.g. as shown by the predetermined spacing X of the marking 14 from the mouth 15 as shown in Figure 2. Thereafter, the liner 11 is introduced, and will then overlie the mouths of all of the laterals.

Following introduction of the liner 11, the mouths of the laterals can then be located using a magnetic detection device which travels along the interior of the liner 11 and which is a sensitive device which can respond to the presence of small magnetic fields. Conveniently, the magnetic sensing device is a flux gate magnetometer, which will be adjusted initially in order to compensate for any stray magnetic fields prior to travelling along the length of the liner 11. The magnetometer is able to magnetically detect the predetermined positions of all of the markings 14, which enables a cutter to be applied to the wall of the liner 11, following the detection of the position of each marking, and at a position which is in registry with the mouth of the lateral. The cutter can then be operated in order to cut through the wall of the liner in order to communicate accurately with the mouth of the lateral.

By applying the marking 14 at a predetermined position in relation to the mouth 15 of each lateral, as shown in Figure 2, the cutter can be spaced by the same distance from the magnetometer on a common mobile device, so that it can be brought automatically into the required position for cutting through the wall of the liner in registry with the mouth of the lateral when the magnetometer has been positioned over the marking. There is therefore no need to move the magnetometer out of the way, following detection of the position of the marking, prior to positioning and then operation of the cutter.

Referring now to Figure 3, there is shown schematically a robot 16 which can travel along the interior of the sewer 10 (prior to introduction of the liner 11) in order to carry out visual inspection of the sewer, locate each lateral, and apply the marking composition at a predetermined position relative to the mouth of each lateral. The robot 16 is capable of being remotely operated, and is drawn by a cable 17, though it could be self-propelled, if desired. The robot 16 carries a television camera 18 (CCTV camera) which can be used to carry out visual inspection of the interior of the sewer which can be remotely observed. The robot 16 also carries an applicator 19 which can be remotely operated in order to apply the marking material at the required position following observation of the mouth of each lateral by the camera 18.

Following operation of the robot 16, to apply markings 14 in a predetermined position relative to the mouth of each lateral as shown in Figure 2, the liner 11 is then introduced in any of the manners referred to above. A further robot 20 may then be used in order to carry out detection of the position of the mouth of each lateral, as shown in Figure 4. The robot 20 carries a detector 21 which is the magnetic detecting device and a cutter 22 which is arranged on the robot 20 in a predetermined arrangement relative to the detector 21, corresponding with the predetermined positioning of the identifiable marking 14 relative to the mouth of each lateral. The robot 20 may also be arranged to be drawn, pushed or to be self-propelled along the interior of the new liner 11. Once the detector 21 has responded accurately to the position of each identifiable marking, the cutter 22 can then be operated, without further adjustment of position, in order to cut through the wall of the liner, which should be accurately in registry with the mouth of the corresponding lateral.

The robots 16 and 20 are shown in Figures 3 and 4 in schematic form only. It should be understood that, if desired, the components of the robots 16 and 20 may be incorporated in a single robot, which is operated in order to carry out both phases of the renovation technique, namely running along the existing

sewer 10 prior to, and after introduction of the liner 11.

#### CLAIMS

- 5 1. A method of re-lining a run of an existing sewer having at least one lateral sewer line connected thereto, the method comprising:
  - applying an identifiable marking to the wall of the existing sewer or lateral, the marking
  - 10 being applied at a predetermined position relative to the mouth by which the lateral is connected to the sewer, and the marking being formed from a composition which includes magnetically detectable material;
  - 15 introducing a liner of plastics material into the run of the existing sewer, which liner overlies the mouth of the lateral;
  - magnetically detecting the predetermined position of the marking;
  - 20 applying a cutter to the wall of the liner, following detection of the position of the marking, at a position which is in registry with the mouth of the lateral;
  - and cutting-through the wall of the liner to
  - 25 communicate with the mouth of the lateral.
2. A method according to claim 1, in which the marking composition is liquid or semi-liquid based, and is applied in the manner of a spot or blob of paint or paste.
- 30 3. A method according to claim 2, in which the magnetically detectable component of the marking composition comprises fine magnetic particles which are held in a carrier medium.
4. A method according to any one of the
- 35 preceding claims, in which the cutter and detecting device is moved along the liner, following each step of lateral locationing and subsequent liner wall piercing, to carry out detection and hole-forming at the next lateral
- 40 location covered by the liner, or by another liner.
5. A method according to any one of the preceding claims, in which a magnetometer is used to detect the predetermined position of
- 45 the marking.
6. A method according to claim 5, in which the magnetometer is a flux gate magnetometer.
7. A method according to any one of the
- 50 preceding claims, in which the identifiable marking is applied on the wall of the sewer at a position near to the mouth of the lateral, or on the wall of the lateral sewer connection.
8. A method according to any one of the
- 55 preceding claims, in which the marking is applied using a remotely operated robot which carries a television camera for visual inspection of the lateral during an initial survey or inspection of the sewer run.
9. A method according to claim 8, in which
- 60 the robot carries an applicator which is remotely operated in order to apply the marking material at the required position following observation of the mouth of the lateral by the
- 65 camera.

10. A method according to any one of claims 1 to 7, in which the magnetic detecting device and the cutter are provided on a separately operated robot which is drawn, pushed or self-propelled along the interior of the new liner in order to locate each lateral and then form a hole in the wall of the liner in registry with the mouth of the lateral.

11. A method according to claim 8 or 9, in which the magnetic detecting device and the cutter are mounted on said robot.

12. A method according to any one of the preceding claims, in which the new liner which is introduced into the existing sewer run is pre-formed by extrusion, and then mechanically fed into, or drawn along the sewer run.

13. A method according to any one of claims 1 to 11, in which the new liner which is introduced into the existing sewer run is formed simultaneously with its being positioned adjacent to the inner wall of the sewer.

14. Sewer re-lining apparatus for carrying out a method according to any one of the preceding claims.

15. A method according to claim 1 and substantially as hereinbefore described with reference to, and as shown in the accompanying drawing.

16. Apparatus according to claim 14 and substantially as hereinbefore described with reference to, and as shown in the accompanying drawing.

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